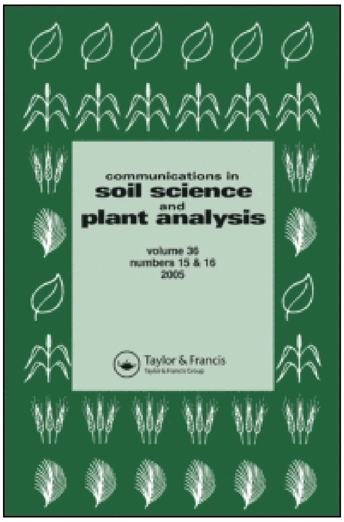

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Enzyme activities in appalachian soils: 2. Urease

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ENZYME ACTIVITIES IN APPALACHIAN SOILS: 2. UREASE

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ABSTRACT : The urease enzyme in many soils plays an important role in the efficient use of urea fertilizer. Urease activities in fourteen hill land soils of the Appalachian region were determined. The two top horizons from each of the soils were sampled in early spring and stored at field moist conditions at 4°C. Observed urease activities varied with soil types, and magnitude of activities were comparable to reported urease activities in other soils. Surface horizons had 1.6 times higher urease activities than subsurface horizons. Relationships between urease activities and soil pH, sand, silt and clay content were nonsignificant. Urease activities were positively related to soil C, N, forms of P and S. CEC, and original moisture content. Each soil type had its own inherent level of urease activity. The urease levels found in these hill-land soils would suggest that urea could be effectively used as N fertilizer source in the Appalachian region.

INTRODUCTION

Urease (urea amidohydrolase EC 3.5.1.5), the enzyme that catalyzes the hydrolysis of urea to CO_2 and NH_3, is very widely distributed in nature, and has been detected in plants, animals, and microorganisms (1,2). Urease plays an important role in the efficient use of urea fertilizer in many soils. A low urease activity might cause added urea to be lost by leaching; on the other hand, a higher activity might result in excessive hydrolysis of added urea and subsequently ammonia can be lost by volatilization (1,3).

Variations in urease activities within and between soil groups have been related to soil properties, type of vegetation, and cultural practices (4,5,6,7,8). A high degree of correlation between urease activities and organic C has been reported in various types of soils (4,6,7,8,9). Studies with fifteen Trinidad soils (4) and twenty-one Iowa soils (8) have shown that urease activities were highly correlated with organic C, total N, CEC, and clay. A decrease in urease activity with soil depth was closely associated with a decrease in organic matter content (9,10). Pancholy and Rice (11), however, found poor correlation between urease activity and organic C content of soil.

Soil pH is either known to increase or decrease urease activity (4,6,8,12,13). Many soils of the Appalachian region are situated on steep terrain and are thus not easily accessible. For such areas, urea is an attractive alternative N source because it has a high N content, and therefore, a lower transportation cost. The efficient use of urea in these hill lands is probably dependent upon urease activities. Surface soils are known to contain high levels of organic matter, while subsurface horizons are lower in organic C content, higher in clay content, and acidic. The objectives of the present study were to measure the magnitude of urease activities in the top two horizons of the major hill land soils of Appalachia and to assess the relationships between urease activities and soil properties.

MATERIALS AND METHODS

Soils and Soil Analysis : The top two horizons from 14 major hill land soils of the Appalachian region were collected in early spring and immediately passed through a 2-mm sieve and stored at 4°C in a field moist condition. Soil groups and their properties are given in the earlier paper by Baligar and Wright (14). The range and mean of soil properties are listed in Table 1.

The moisture content of the samples was determined by drying soils for 48 hours at 105°C. The percent water content was multiplied by bulk density (BD) to obtain volumetric water content. Bulk density was estimated by taking 60 mm soil cores of known volume. The percent water filled porosity (% WFP) was determined according to Linn and Doran (15). Soil pH was measured in water at a soil to solution ratio of 1:1. Soils were analyzed for exchangeable bases (16), exchangeable acidity, and exchangeable Al (17). Bray extractable P (BP) and S (ES) were determined by extracting soil with Bray-l reagent (0.025 N HCl + 0.03 M NH_4F). The S in the extractant was determined using inductively coupled plasma emission spectroscopy (ICP). Phosphorus in extractant was detected by a color development method (18). Organic P (OP) was detected by the method of Olsen and Summers (18). Organic S (OS) was computed by taking the differences

TABLE 1
Range and Mean of Physical and Chemical Properties of Soils Used

Property	Surface Horizons		Subsurface Horizons	
	Range	Mean	Range	Mean
Clay[a]	25.7 - 222.7	90.2	39.9 - 292.5	142.1
Sand[a]	122.4 - 809.0	515.0	81.3 - 793.7	419.3
Silt[a]	140.3 - 658.9	394.8	166.4 - 651.7	438.6
pH-H_2O	3.3 - 6.0	4.2	3.4 - 6.4	4.2
C[a]	11.7 - 288.8	74.6	4.7 - 57.6	22.7
N[a]	1.1 - 14.7	4.6	0.5 - 4.8	1.9
Organic P (OP)[b]	18.7 - 472.9	197.8	19.0 - 398.7	134.9
Bray-ext P (BP)[b]	0.1 - 75.7	18.2	0.1 - 37.7	3.7
Organic S (OS)[b]	43.1 -1082.1	375.9	0.0 - 328.4	97.8
Extractable S (ES)[b]	15.6 - 97.9	42.9	12.9 - 101.1	50.4
Bases (EB)[c]	0.56- 16.50	5.5	0.15- 8.79	2.26
CEC[d]	2.11 - 17.07	7.92	1.10- 11.7	4.96

[a] g kg^{-1} soil.
[b] mg kg^{-1} soil.
[c] EB = Σcmol kg^{-1} of (K + Na + Ca + Mg).
[d] CEC = Σcmol kg^{-1} of (EB + Al + H).

between total S obtained using a Leco analyzer (Leco SC 132, St. Joseph, MI)[a] and extractable S from the Bray-l extractant. Total C and N were determined using Leco CHN 600.

Assay of Urease : Urease activity was assayed by the method of Tabatabai and Bremner (19) and Tabatabai (20), which is based on the determination of NH_4^+ released upon hydrolysis of urea. Five grams of soil are incubated with THAM buffer, substrate solution, and toluene at 37°C for 2 hours. The NH_4^+ released was extracted from the incubated soil by 2 M KCl containing $AgSO_4$ and measured using a Technicon Auto Analyzer II.

Statistical Methods: Duncan's Multiple Range Test (DMRT) was used to test for significant differences among enzyme activities in different profiles. Simple correlation coefficients (r) relating urease activity to soil properties were obtained using the Statistical Analysis System (SAS) program.

[a]The use of trade names does not imply endorsement by the U.S. Department of Agriculture of the products named, nor criticism of similar ones not mentioned.

RESULTS AND DISCUSSION

With a few exceptions, higher urease activities were found in surface horizons than in subsurface horizons (Table 2). On an average, surface horizons had 1.6-fold higher activities than subsurface horizons. In many soils, a decline in urease activity with depth has been attributed to a decline in soil organic C content (1,2). In the current study, surface horizons had an averaged organic content more than 3-fold higher than subsurface horizons (14). The urease activity values obtained are comparable to those reported for various other soil types (1,10). Many workers have reported wide variations in urease activities in various soil groups, and such variations in activities have been attributed to soil physical and chemical properties, the nature of vegetation, and cultural methods (4,6,7,8,12, 21).

Correlation coefficients relating urease activities and soil properties are shown in Table 3. Urease activities were positively related to moisture by weight,(OMW) and volumetric moisture content (OMV). Relationships between urease activities and soil pH were not significant. Similar trends have also been reported for five great soil groups from northern New South Wales (11) and Iowa soils (8). The relationships between urease activities and sand, silt, and clay content were not significant. Significant and positive relationships between clay content and urease activities have been reported for Iowa soils (8) and Trinidad soils (4). In ten surface noncultivated California soils, Frankenberger and Dick (5) have reported a positive relationship between UR activities and soil clay content and a negative relationship between UR activities and sand content.

Highly significant and positive relationships were observed between urease activities and organic C and total N content of soil. A high degree of correlation between urease activities and organic C and N has been reported in several other soils (2,4,8,9,13). A significant and positive relationship between urease activity and soil C content might be due to a higher level of microbial biomass and a greater stabilization of extracellular urease by humic molecules (21,22,23). Urease activities were positively related to various forms of P and S; however, the relations were only significant for organic P and S, possibly, because P and S are closely associated with organic C. Speir (13) has recently reported a positive and negative relation between urease activities and extractable P and S in Cook Island

TABLE 2
Urease Activities in Surface (SH) and Subsurface (SSH) Horizons of Appalachian Soils.[a]

Soil	SH	SSH
Ashe	80fh	29fg
Hayesville	54hi	35fg
Watauga	94eg	21gh
Edneytown	46i	39f
Dandridge	237bc	134b
Dunmore	70gi	26fh
Porters	223bc	12h
Tate	304a	206a
Berks	51hi	88cd
DeKalb	253b	198a
Gilpin	216c	203a
Lily	114de	103c
Upshur	108df	62e
Westmoreland	128d	77de
Mean	141	88
LSD (0.05)	30	15

[a]Urease activity µg of NH_4-N-released g $soil^{-1}$ 2 h^{-1}.
[b]Means within a column not followed by the same letter differ at the 0.05 level of probability by Duncan's New Multiple Range Test.

and Tongan soils. Positive relations were observed between urease activities and exchangeable bases (EB), CEC, and Mg/(Mg + Ca) ratios. The high degree of correlation between urease activities and CEC of surface soils is probably due to the organic C content. A high degree of relationship between urease activities and CEC of various types of soil has been reported (4,5,8,13).

CONCLUSIONS

The urease activities detected in 14 major hill land soils of the Appalachian region were comparable to activities reported elsewhere in other types of soil. The urease levels found in these hill land soils would suggest that urea could be used as a N source. The observed urease activities were significantly related to soil organic C, N, P, and S. Urease activities were positively related to Bray-P, extractable S, exchangeable bases, and CEC.

TABLE 3

Correlation Coefficients (r) Relating Urease Activities and Selected Soil Properties of All (AH), Surface (SH) and Subsurface (SSH) Horizons of Appalachian Soils

Properties	AH	SH	SSH
Physical			
Orig. moist wt. (OMW)	0.75**	0.79**	0.61*
Orig. moist vol. (OMV)	0.55**	0.62*	0.31NS
WFP %	0.39*	0.53NS	-0.03NS
Clay	-0.12NS	0.21NS	-0.19NS
Sand	0.06NS	0.01NS	-0.08NS
Silt	-0.02NS	-0.09NS	0.19NS
Chemical			
pH-H_2O	-0.15NS	-0.08NS	-0.26NS
C	0.71**	0.72**	0.83**
N	0.67**	0.69**	0.73**
Organic P (OP)	0.81**	0.93**	0.58*
Bray-Ext P (BP)	0.47**	0.52NS	0.11NS
Total S (TS)	0.75**	0.82**	0.54NS
Organic S (OS)	0.75**	0.82**	0.60*
Extractable S (ES)	0.40*	0.76**	0.20NS
Ex Bases (EB)	0.44**	0.52NS	0.02NS
CEC	0.63**	0.71**	0.31NS
Mg/(Mg + Ca)	0.45*	0.51NS	0.06NS

*, ** Significant at 0.05 and 0.01 levels of probability.
[a]NS = Not significant.

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